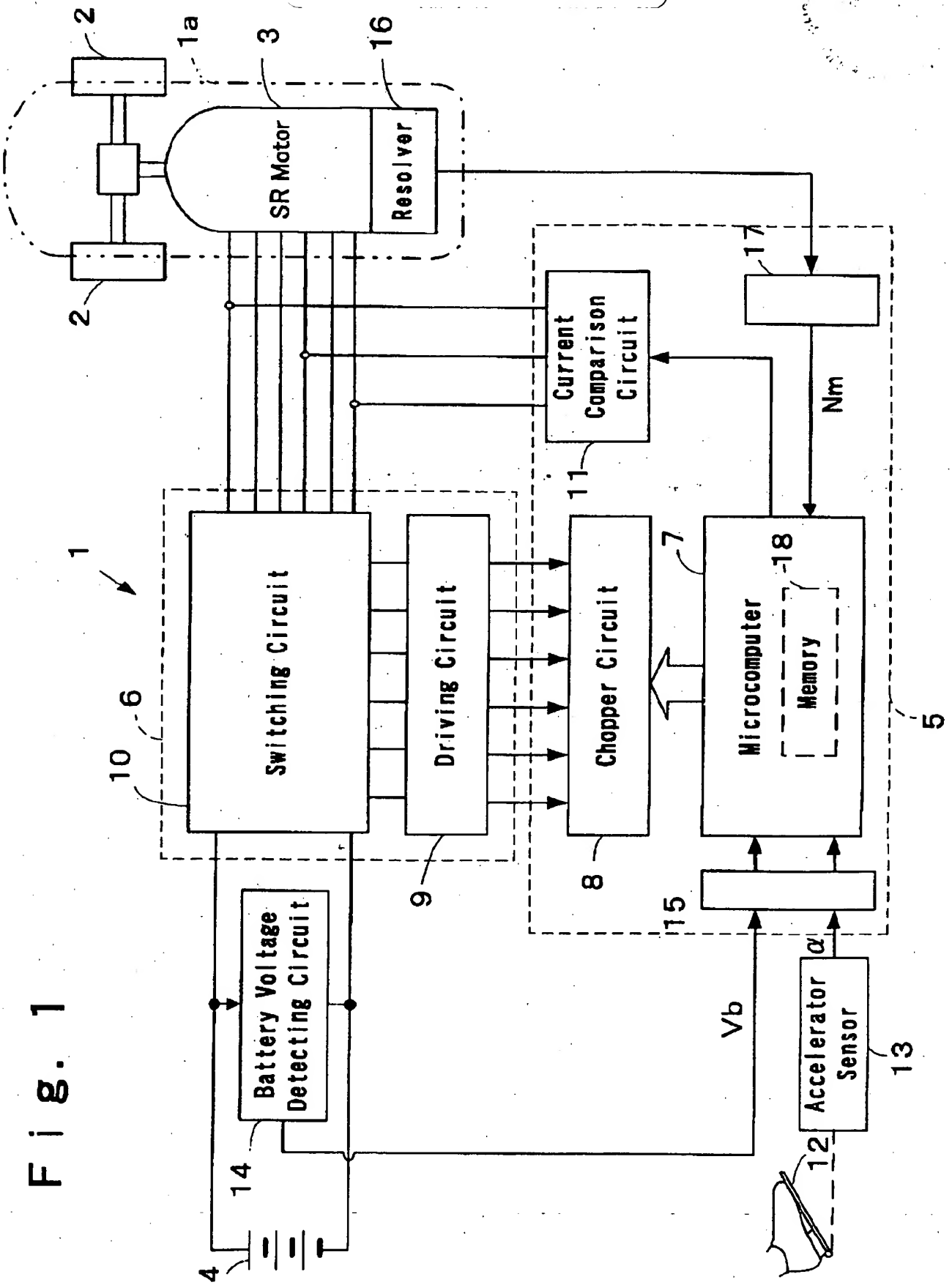

2
1a
3
16
SR Motor
Resolver
2
17
Current Comparison Circuit
Nm
11
1
Switching Circuit
Driving Circuit
Chopper Circuit
7
18
Microcomputer
Memory
5
10
6
9
8
15
Battery Voltage Detecting Circuit
14
4
Vb
α
Accelerator Sensor
13
12

Fig. 1

Fig. 2

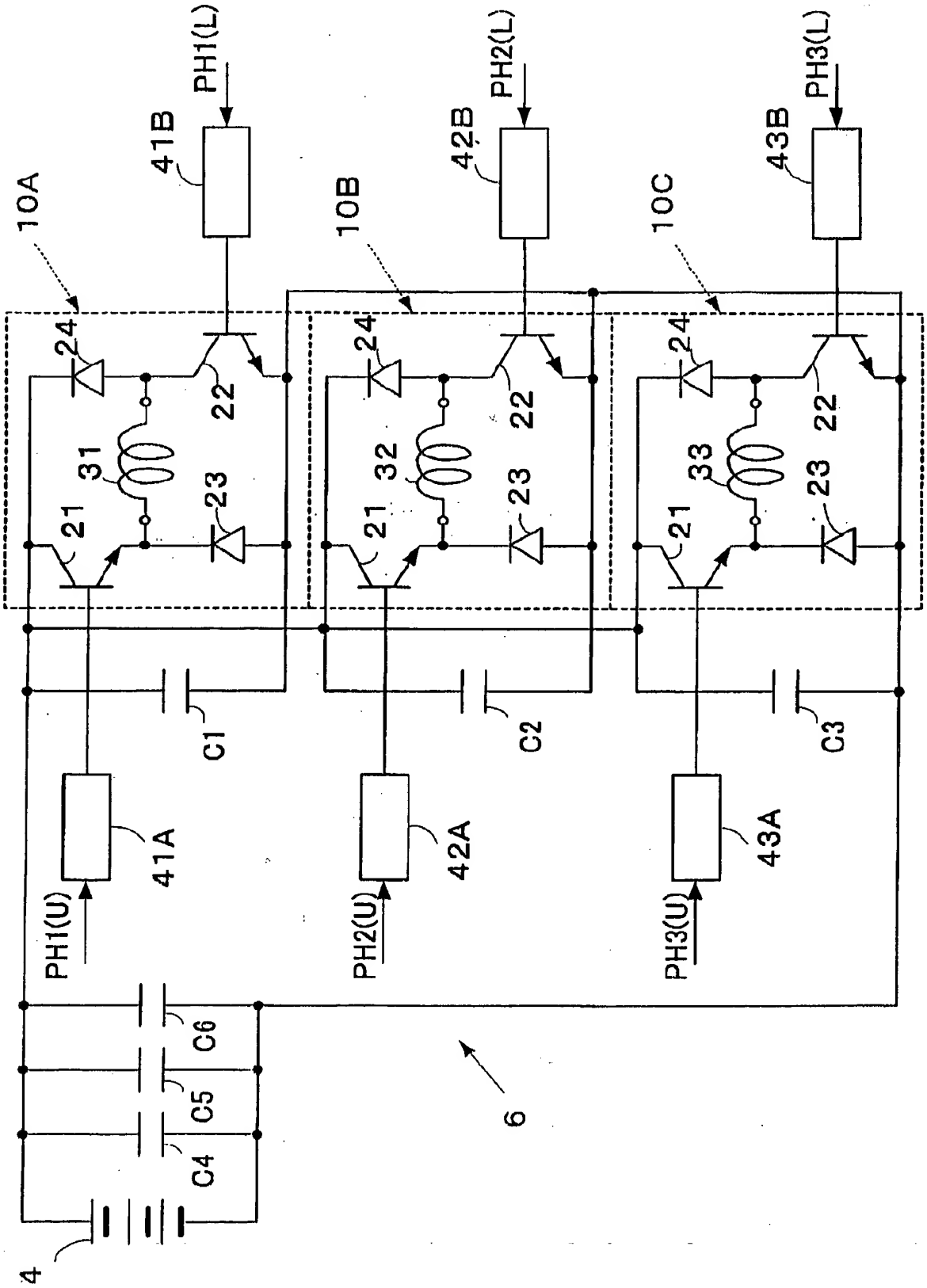

PH1(L)
PH2(L)
PH3(L)
41B
42B
43B
10A
10B
10C
24
22
31
32
33
23
21
C1
C2
C3
41A
42A
43A
PH1(U)
PH2(U)
PH3(U)
C6
C5
C4
4
6

Fig. 5

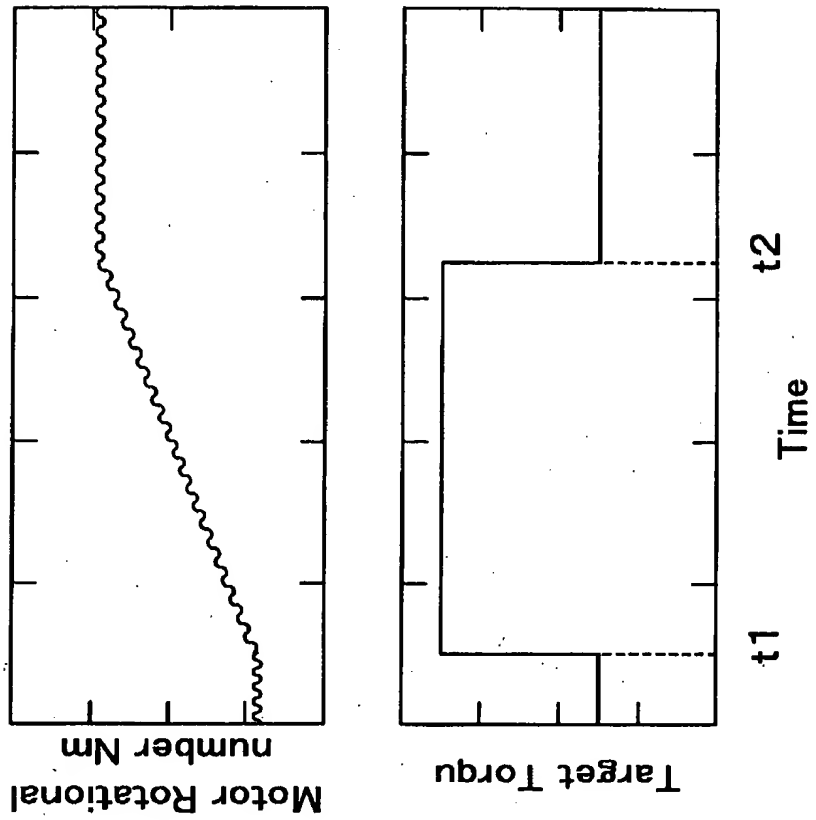

Motor Rotational number Nm
Target Torqu
t1
t2
Time

Fig. 3

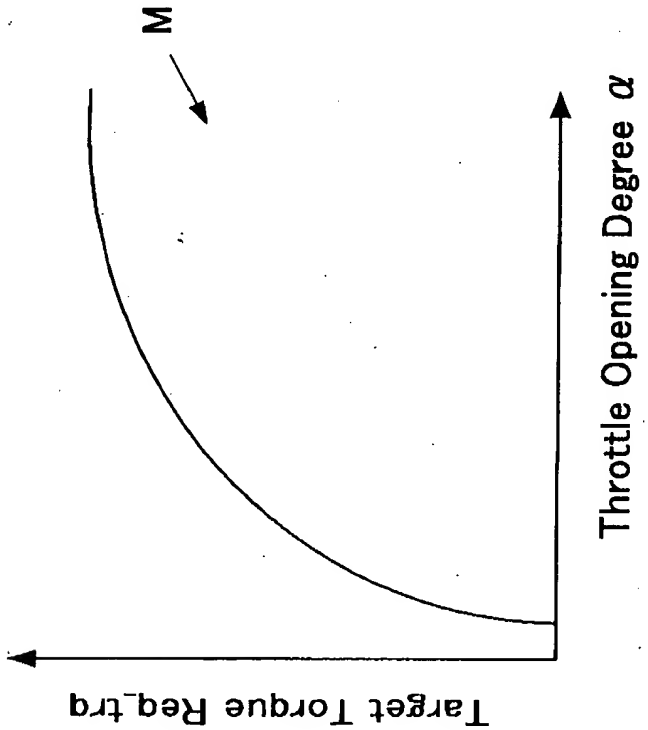

M
Throttle Opening Degree α
Target Torque Req_trq

Fig. 4

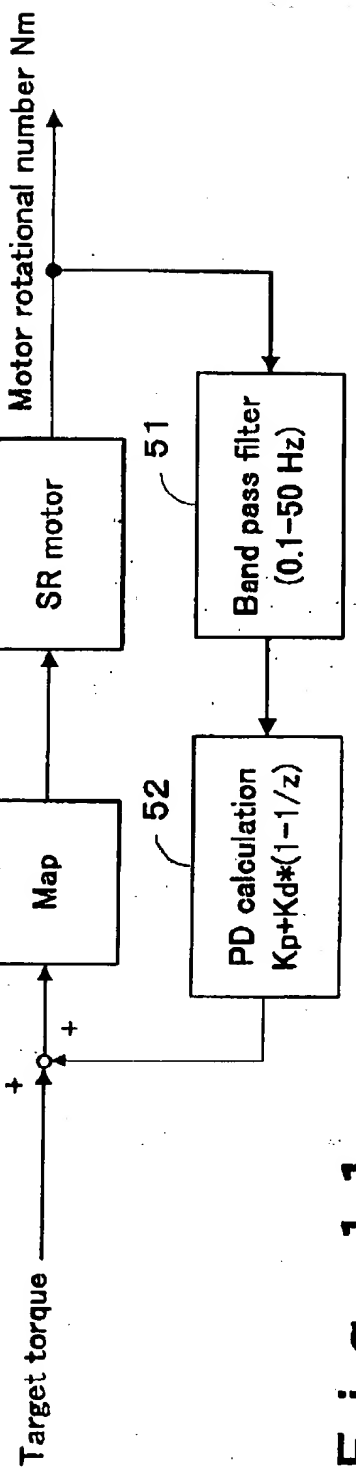

Motor rotational number Nm
3
SR motor
51
Band pass filter
(0.1-50 Hz)
MP
Map
52
PD calculation
Kp+Kd*(1-1/z)
+
+
Target torque

Fig. 11

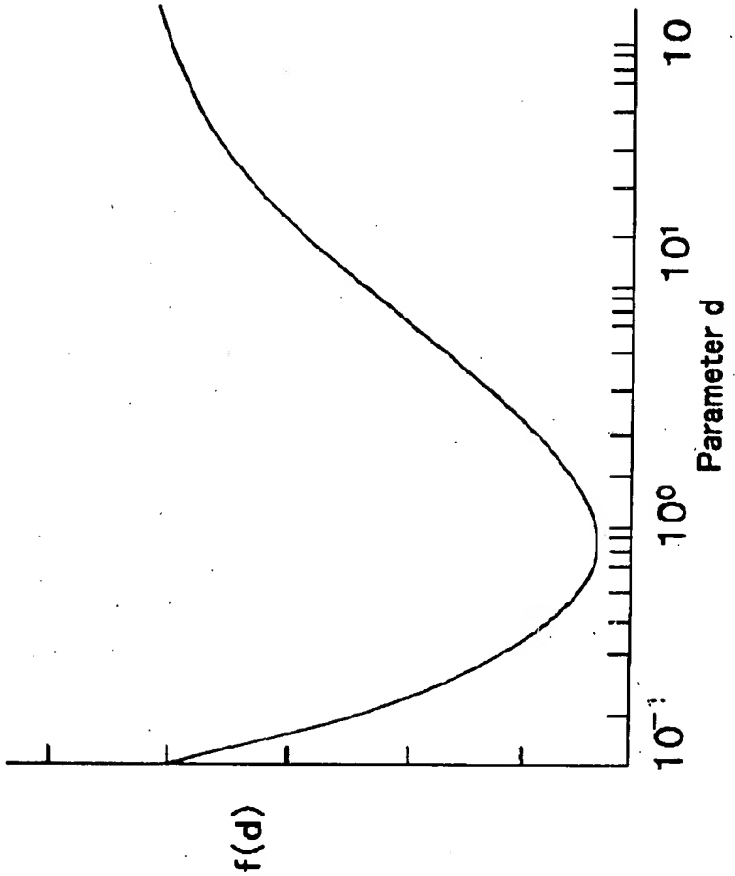

f(d)
$10^{-1}$
$10^{0}$
$10^{1}$
10
Parameter d

Fig. 6

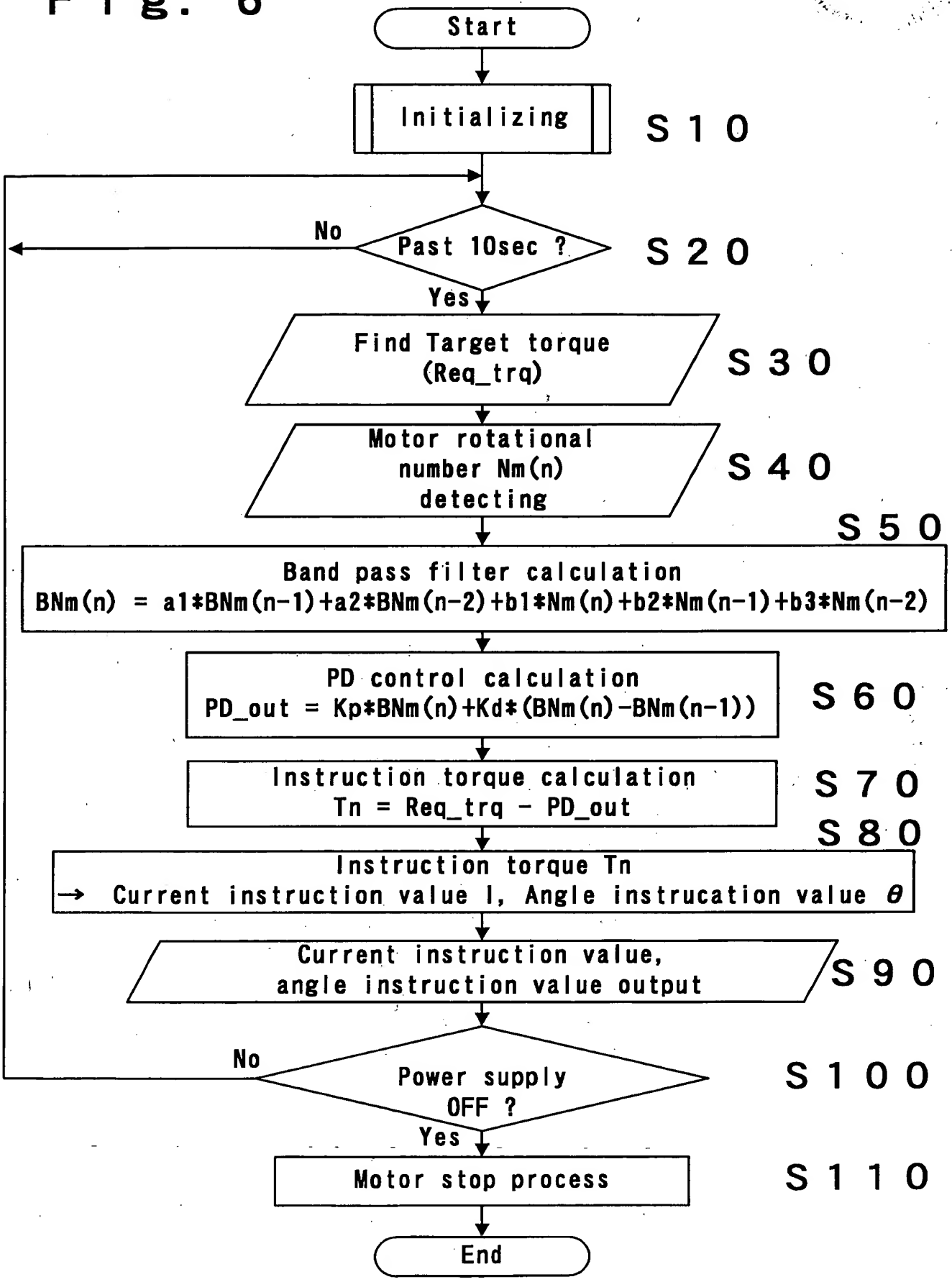

Start
Initializing
S10
No
Past 10sec ?
S20
Yes
Find Target torque (Req_trq)
S30
Motor rotational number Nm(n) detecting
S40
S50
Band pass filter calculation
BNm(n) = a1*BNm(n-1)+a2*BNm(n-2)+b1*Nm(n)+b2*Nm(n-1)+b3*Nm(n-2)
PD control calculation
PD_out = Kp*BNm(n)+Kd*(BNm(n)-BNm(n-1))
S60
Instruction torque calculation
Tn = Req_trq - PD_out
S70
S80
Instruction torque Tn
→ Current instruction value I, Angle instrucation value θ
Current instruction value, angle instruction value output
S90
No
Power supply OFF ?
S100
Yes
Motor stop process
S110
End

Fig. 7

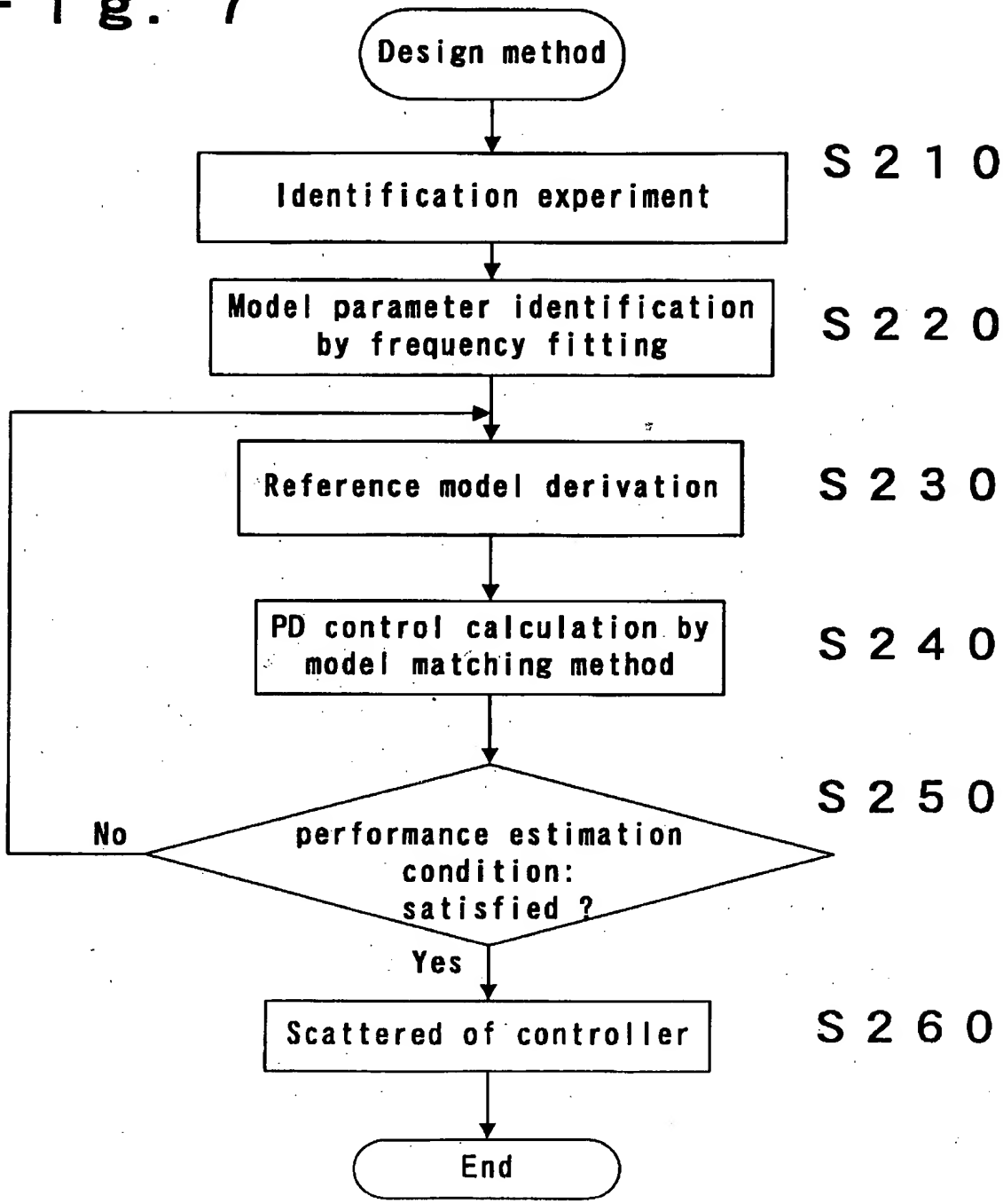

Design method
Identification experiment
S210
Model parameter identification by frequency fitting
S220
Reference model derivation
S230
PD control calculation by model matching method
S240
performance estimation condition: satisfied ?
S250
No
Yes
Scattered of controller
S260
End

Fig. 8

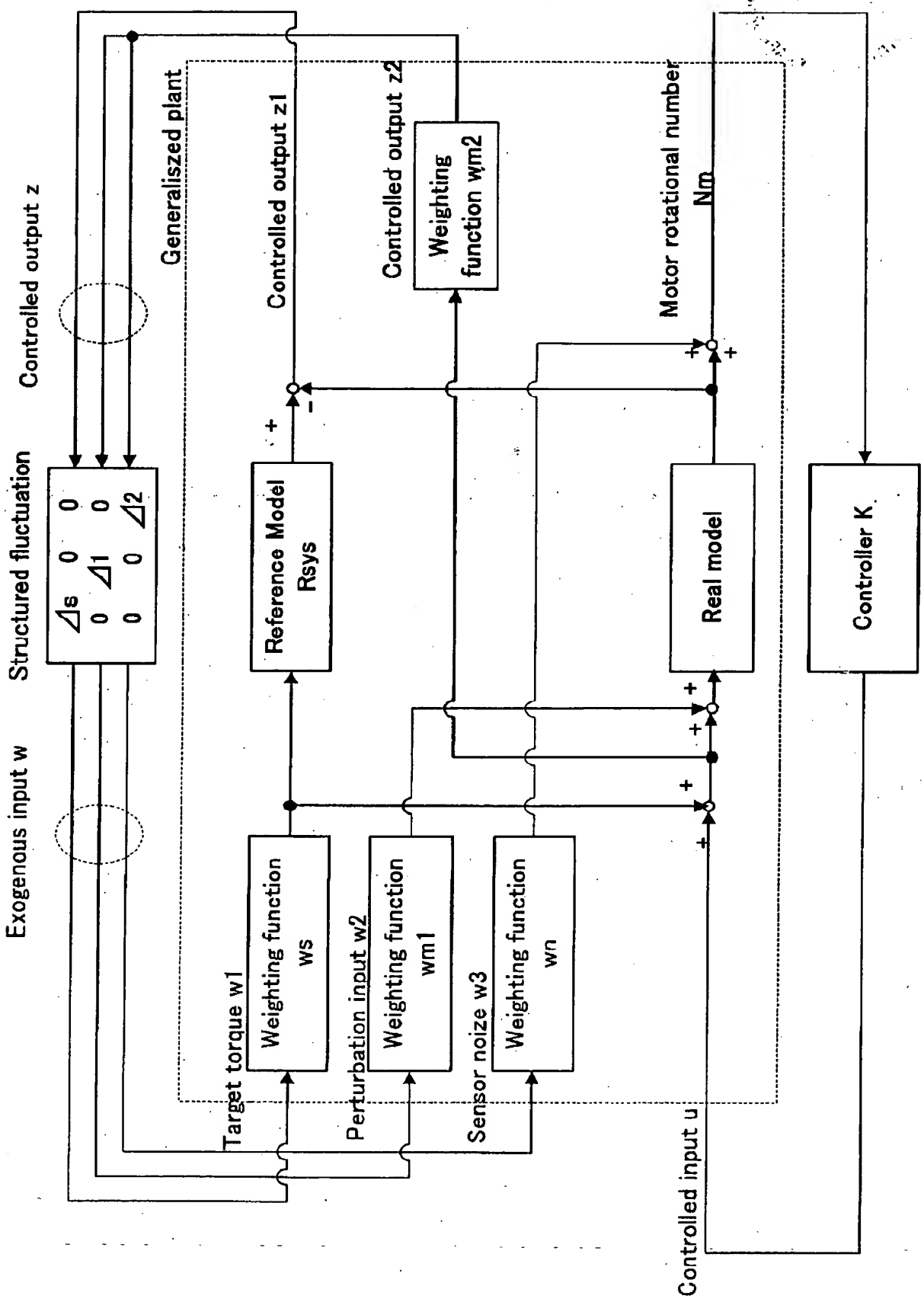

Exogenous input w
Structured fluctuation
Controlled output z
Generalized plant
Controlled output z1
Controlled output z2
Motor rotational number Nm
Reference Model Rsys
Real model
Controller K
Weighting function ws
Weighting function wm1
Weighting function wn
Weighting function wm2
Target torque w1
Perturbation input w2
Sensor noize w3
Controlled input u
Δs 0 0
0 Δ1 0
0 0 Δ2

Fig. 9 (a)

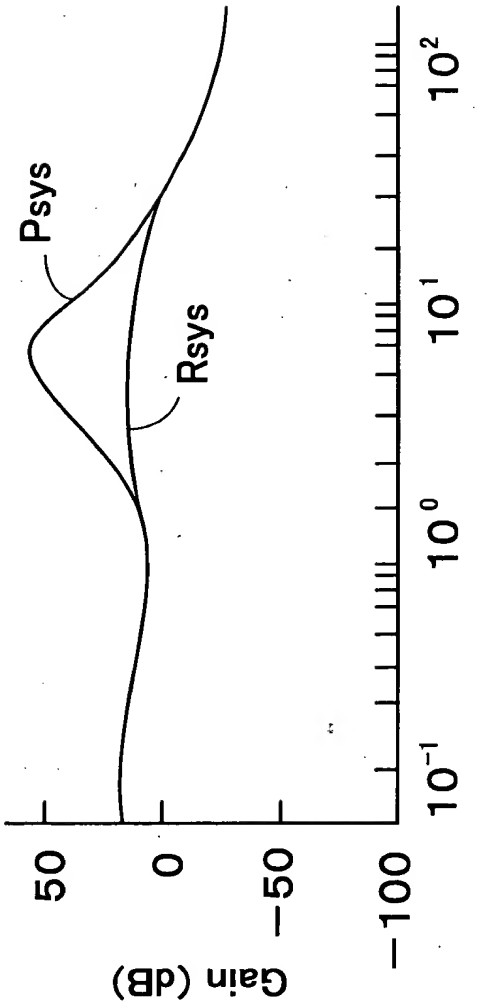

Psys
Rsys
50
0
−50
−100
Gain (dB)
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
Frequency(Hz)

Fig. 9 (b)

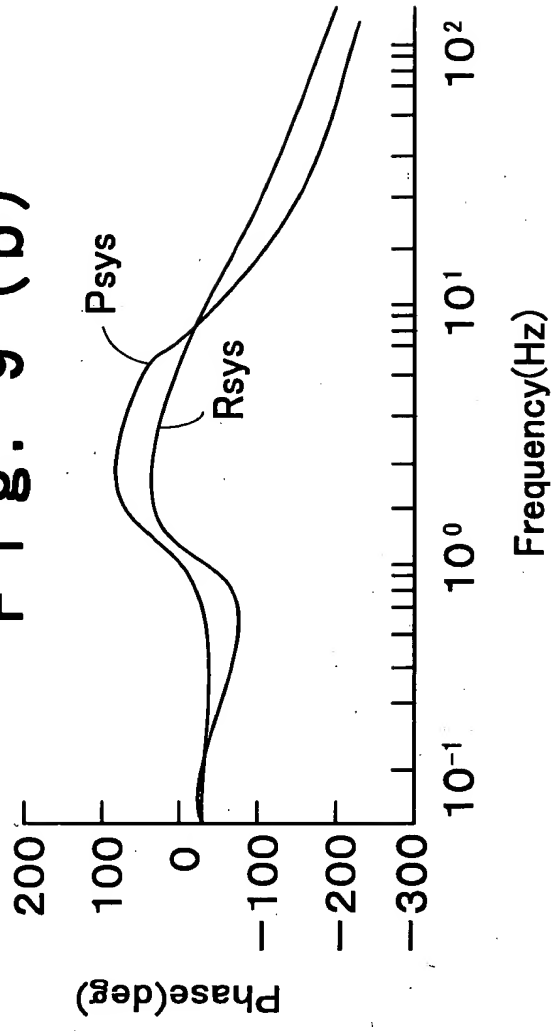

Psys
Rsys
200
100
0
−100
−200
−300
Phase(deg)
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
Frequency(Hz)

Fig. 10

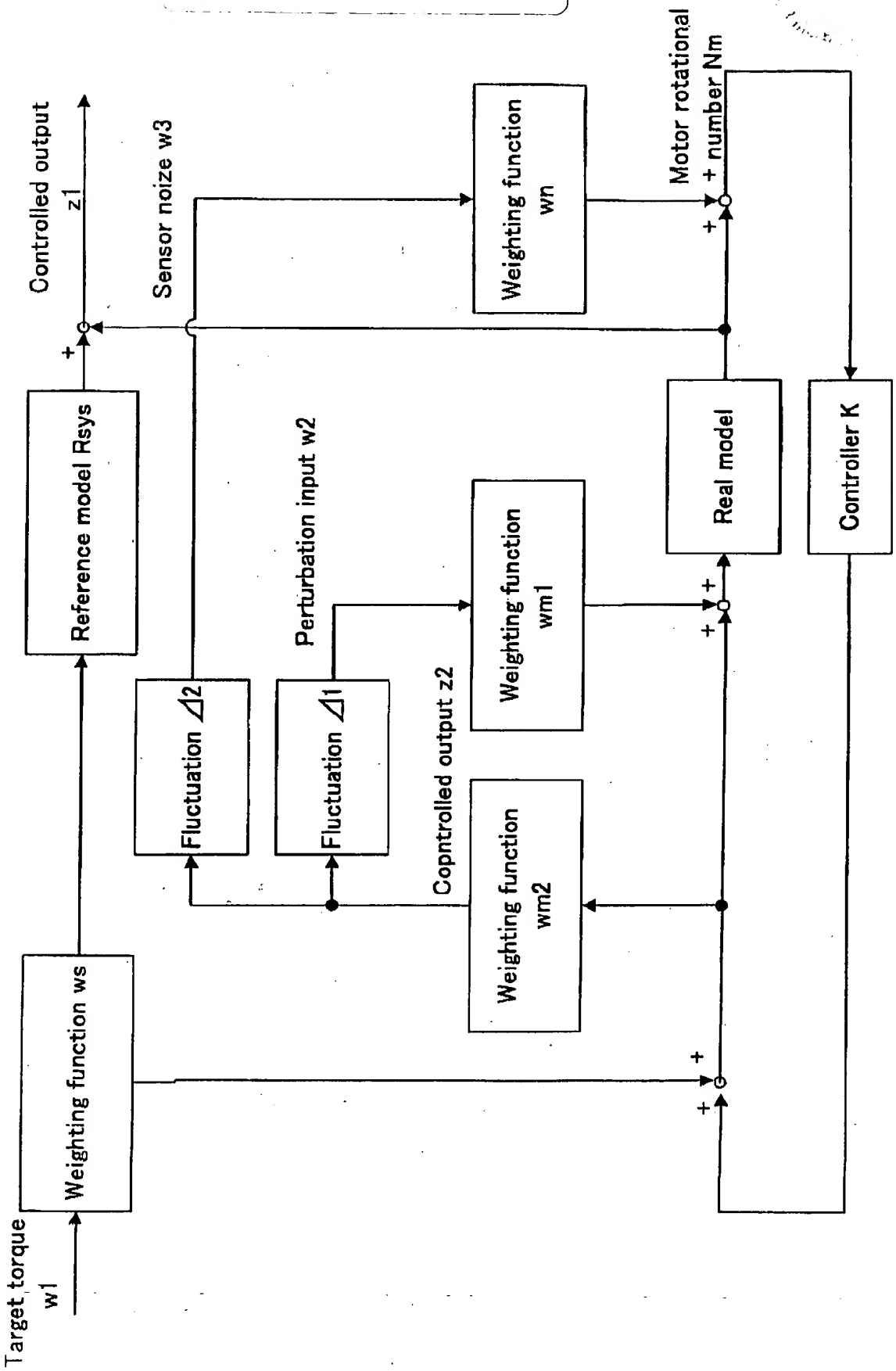

Target torque w1
Weighting function ws
Reference model Rsys
Controlled output z1
Sensor noize w3
Weighting function wn
Motor rotational + number Nm
Perturbation input w2
Fluctuation Δ2
Fluctuation Δ1
Copntrolled output z2
Weighting function wm1
Weighting function wm2
Real model
Controller K
+
-

Fig. 12

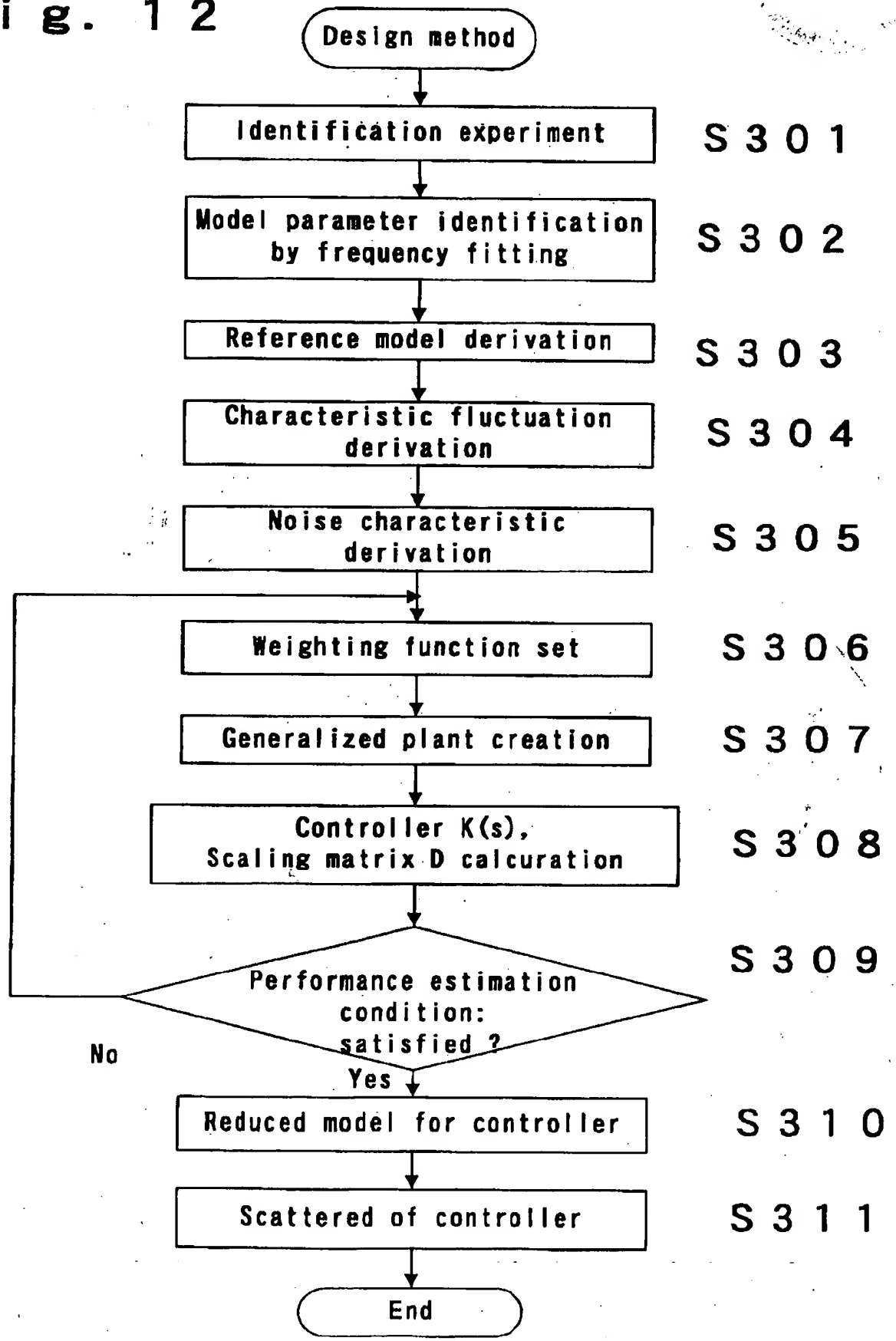

Design method
Identification experiment
S301
Model parameter identification by frequency fitting
S302
Reference model derivation
S303
Characteristic fluctuation derivation
S304
Noise characteristic derivation
S305
Weighting function set
S306
Generalized plant creation
S307
Controller K(s), Scaling matrix D calcuration
S308
Performance estimation condition: satisfied ?
S309
No
Yes
Reduced model for controller
S310
Scattered of controller
S311
End

Fig. 13

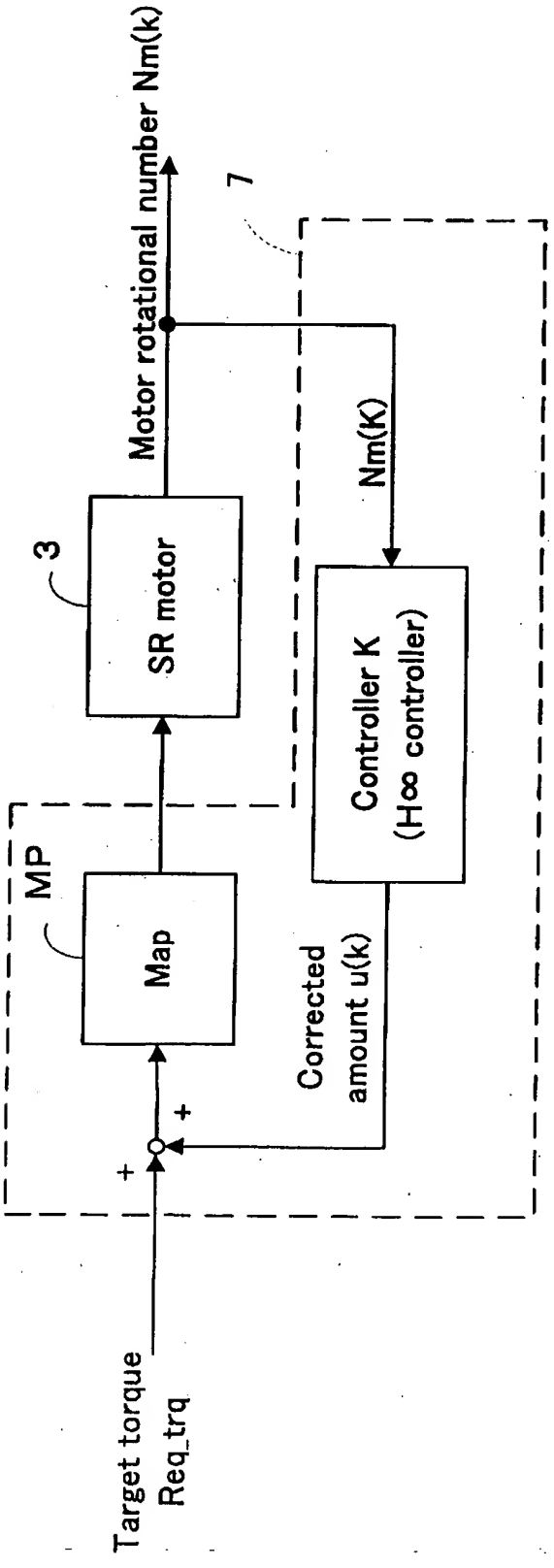

Motor rotational number Nm(k)
7
Nm(K)
3
SR motor
Controller K
(H∞ controller)
MP
Map
Corrected
amount u(k)
+
+
Target torque
Req_trq

Fig. 16

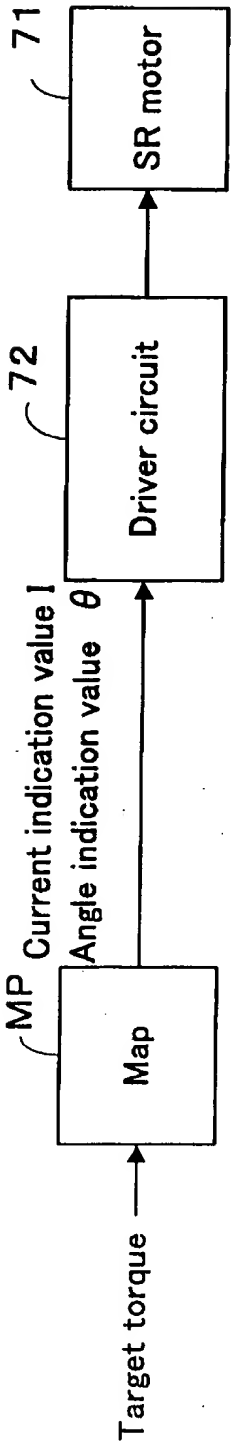

71
SR motor
72
Driver circuit
Current indication value I
Angle indication value θ
MP
Map
Target torque

Fig. 14

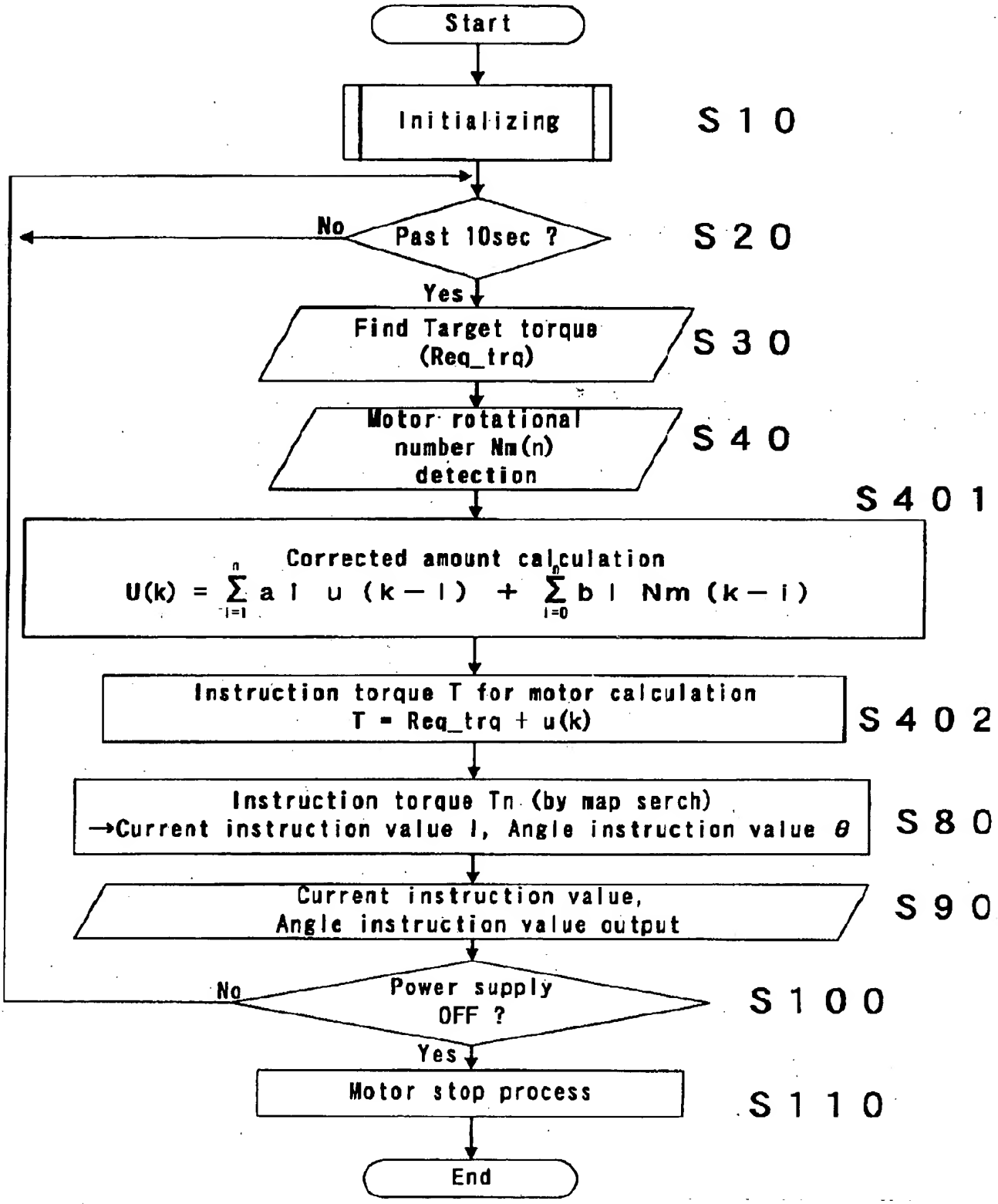

Start
Initializing
S10
No
Past 10sec ?
S20
Yes
Find Target torque (Req_trq)
S30
Motor rotational number Nm(n) detection
S40
S401
Corrected amount calculation
$U(k) = \sum_{i=1}^{n} a_i \, u(k-i) + \sum_{i=0}^{n} b_i \, Nm(k-i)$
Instruction torque T for motor calculation
T = Req_trq + u(k)
S402
Instruction torque Tn (by map serch)
→Current instruction value I, Angle instruction value θ
S80
Current instruction value, Angle instruction value output
S90
No
Power supply OFF ?
S100
Yes
Motor stop process
S110
End

Fig. 15

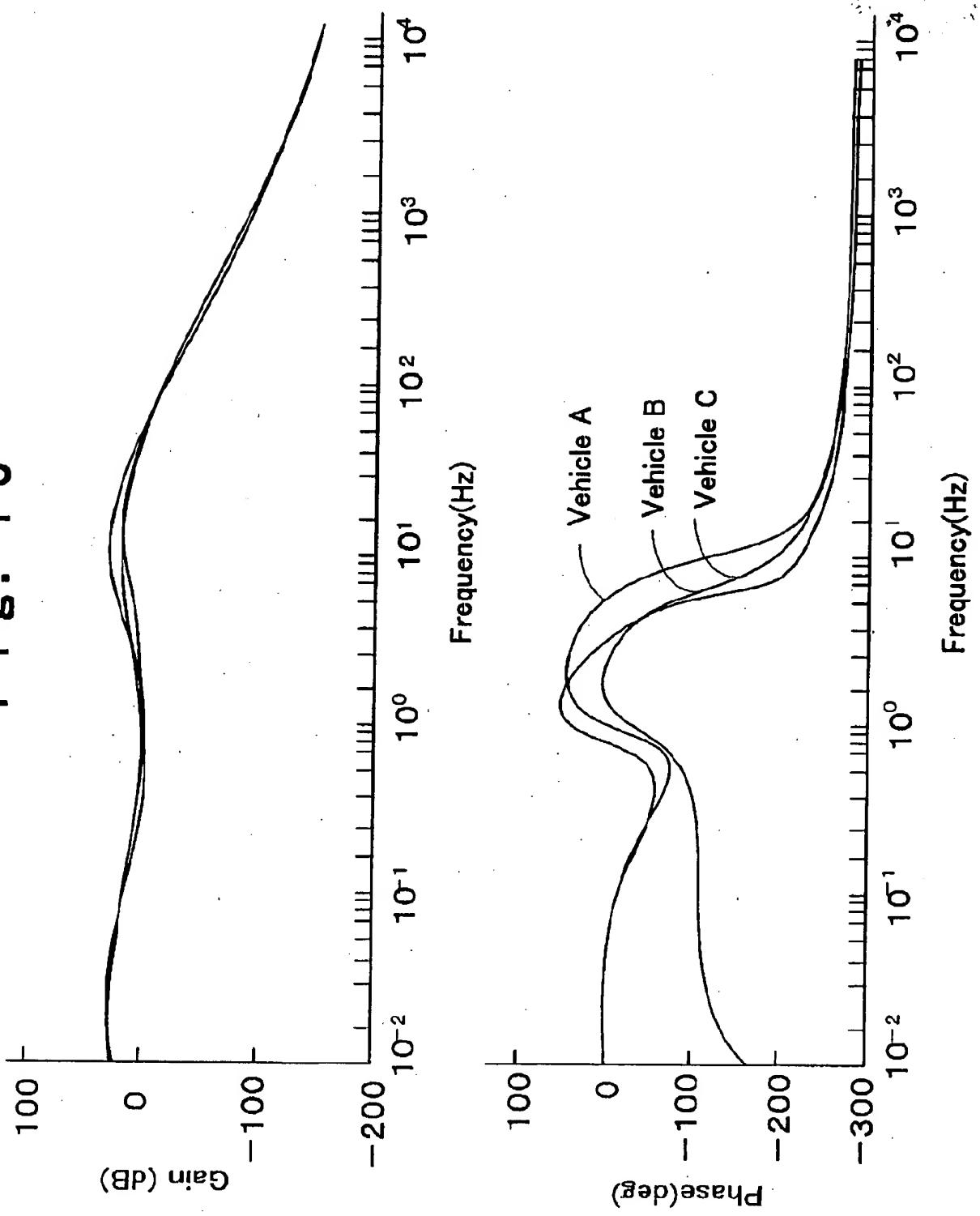

Gain (dB)
100
0
−100
−200
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
$10^{3}$
$10^{4}$
Frequency(Hz)
Phase(deg)
100
0
−100
−200
−300
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$
$10^{3}$
$10^{4}$
Frequency(Hz)
Vehicle A
Vehicle B
Vehicle C

Fig. 17 (a)

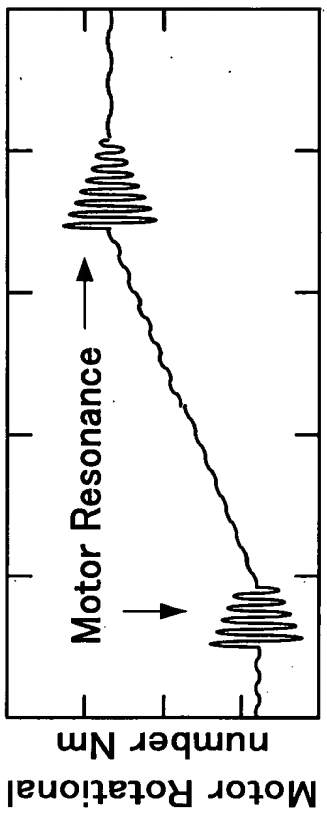



Fig. 17 (b)

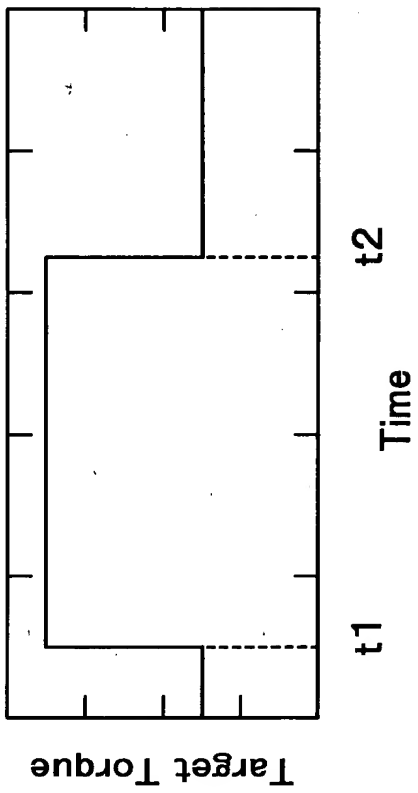


Fig. 18 (a)

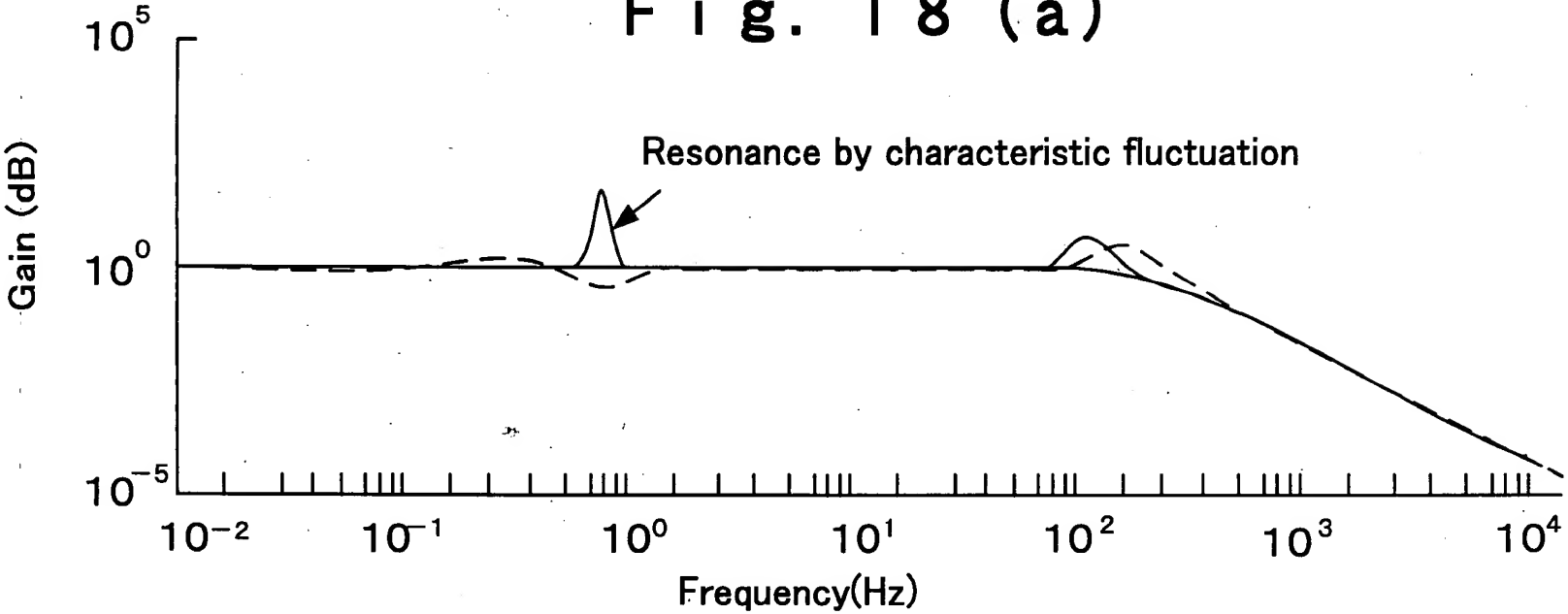
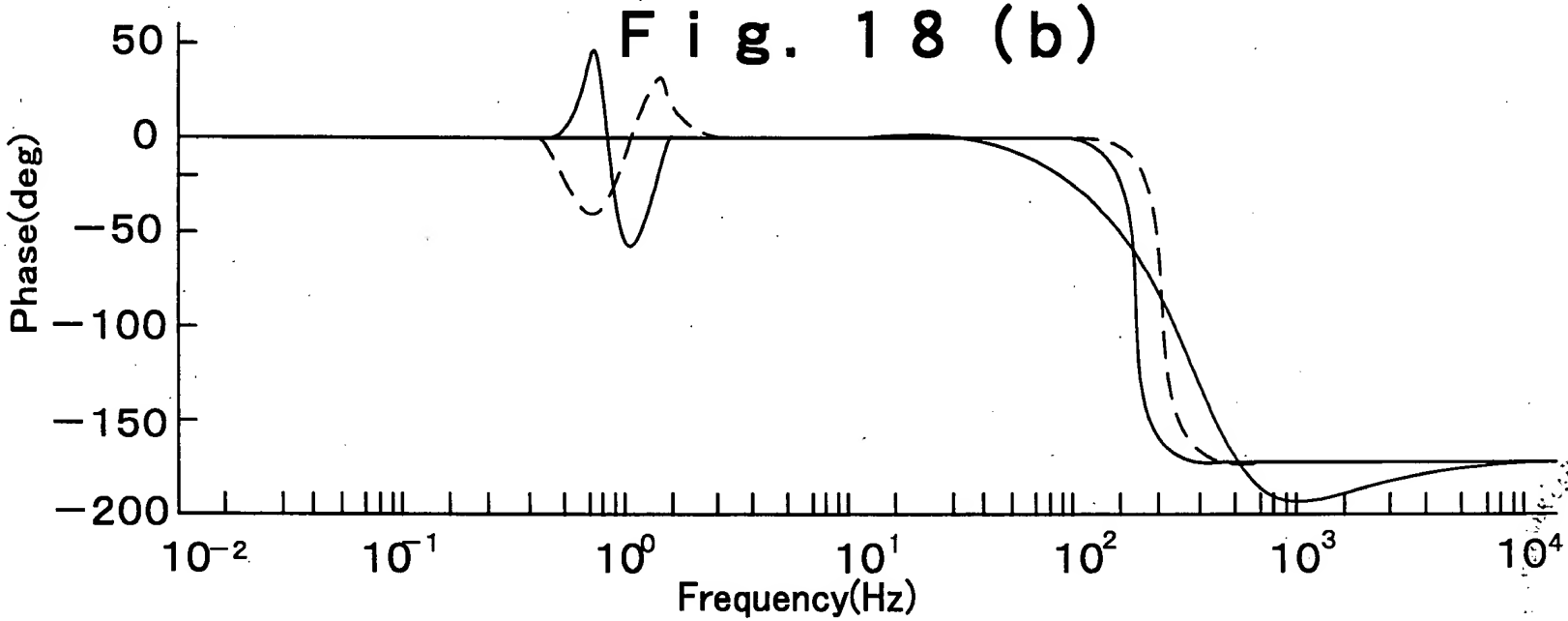



Fig. 18 (b)




Vibration Reduction Control Apparatus for an Electric Motor and Design Method of a vibration Reduction Control for the Electric Motor
Inagaki et al.
Q66363 09/916,283
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